DOCUMENT RESUME

ED 224 458 IR 010 439

AUTHOR Grayson, Lawrence P.
TITLE New Technologies in Education.
PUB DATE 26 May 81
NOTE 38p.; An edited version of this article will appear in the 5th edition of the Encyclopedia of Educational Research, published by the American Educational Research Association (1982).
PUB TYPE Information Analyses (070)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Audio Equipment; *Audiovisual Instruction; Computer Assisted Instruction; *Computer Oriented Programs; Computer Programs; *Educational Media; *Equipment Utilization; *Input Output Devices; Literature Reviews; Technology Transfer; *Telecommunications; Video Equipment

ABSTRACT

Many technologies besides microcomputers and videodiscs have been and are being used effectively in education, and this article provides an overview of the current utilization of a variety of educational technologies. Existing technologies are categorized according to their accessibility, whether used locally or over a distance, and their capability, whether primarily audio and audiographic, computer, or video. The technologies and their typical applications are explored, using an approach which follows the developments in hardware and their uses in education. Audio and audiographic technologies discusssed include radio and audiotapes, telephone, three categories of telewriters, slow-scan television, facsimile, and educational telephone networks. Computer-related topics include expenditures for computing, trends in computer hardware, availability of computers, computer-based instruction, course materials, small and large-scale evaluations of computer-based instruction, computer-assisted testing, and computer conferencing. Video technolgies described include broadcast television, Instructional Television Fixed Service systems, satellites and cable systems, video recording media, and evaluation study results. An extensive 68-item reference list is included. (LMM)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

- This document has been reproduced as received from the person or organization originating it.
  Minor changes have been made to improve reproduction quality.
- Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

IR

ED224458

NEW TECHNOLOGIES IN EDUCATION

Invited contribution for the 1982 edition
of the Encyclopedia of Educational Research

Lawrence P. Grayson
National Institute of Education
Washington, DC. 20208

May 26, 1981

Note: A slightly revised version of this will appear as a chapter in the 5th edition of the Encyclopedia of Educational Research, to be published by the American Educational Research Association in 1982

IR010439

NEW TECHNOLOGIES IN EDUCATION

Lawrence P. Grayson
National Institute of Education
Washington, DC 20208

Throughout most of the history of civilized man, technology has been linked to learning. Generations of students have been taught using first clay tablets and papyrus, later paper-pen-and-ink, the hornbook, chalkboards, books and pictures, and more recently films, records and transparency projectors. In today's world, many learners are receiving instruction by radio, television, electronic sound and visuals stored on tape, the telephone, computer and communications satellite. Further, the present and growing availability of videodiscs, microcomputers, computer graphics and electronic terminals with a high degree of "intelligence", fiber optics, lasers, communications satellites that operate into low-cost terminals, and a large number of devices that function with telephone lines is stimulating the creation of new approaches to learning and providing opportunities to implement applications that were unfeasible, either technically or economically, even in the recent past.

The telephone, for instance, is primarily thought of as a device for conducting conversations. Yet, it can be used to transmit data and a wide variety of graphic and pictorial information, from free-hand drawings to photographs and still pictures to paper facsimiles to computer-generated graphics. For instruction, this means that visuals can accompany the audio information that is transmitted or dialog that takes place. In administrative applications, charts and diagrams can supplement teleconferences to facilitate decision making or the transfer or information. Full-motion video applications of telecommunications provide even greater promise, as new systems make it economically feasible to transmit TV lectures or conduct "face-to-face" seminars among people located over large distances.

For purposes of this review, existing technologies used in education will be categorized according to their accessibility, whether used locally or over distance, and their capability, whether primarily audio and audiographic, computer or video. The technologies to be discussed, together with typical applications of the hardware, are listed according to this classification in Fig. 1. This approach follows the developments in hardware and their uses in education, rather than following the broader approach of viewing the entire learning environment as it interacts with the technology.

A complete study of the role of technology in education would cover numerous aspects of teaching, learning and information delivery, and would go well beyond the scope of a short article. It should treat the types of learning that are facilitated by technology, the roles of teachers and learners, the environment for learning necessitated by technology, procedures for materials development, techniques for evaluating technology-mediated learning, as well as the interplay among the considerations given to planning, implementing and evaluating technology systems, the theories of learning that underpin many technology applications in education, the enormous body of literature research findings that have emerged from the study of media in education, and other aspects of the field that is referred to as educational technology or instructional technology. Educational technology was defined by Grayson (1972) as "a systems approach to instruction, incorporating specific measurable instructional objectives, diagnostic testing, criteria for student performance...and the repeated redesign of the curriculum materials until the criteria are achieved...As defined, educational technology involves the application of scientifically tested principles of learning to an instructional environment in a consistent and coherent manner. It incorporates the media and may involve hardware materials, and methods of instruction. This scope of the subject was adopted in the important reports by Tickton (1970,1971), The Carnegie Commission on Higher Education (1972), and the National Academy of Engineering (1974), as well as for an

CAPABILITY		ACCESSIBILITY			
		USED LOCALLY		USED OVER DISTANCE	
		HARDWARE	TYPICAL APPLICATIONS	HARDWARE	TYPICAL APPLICATIONS
	AUDIO AND AUDIOGRAPHIC	Audio tapes	Stored lectures and discussions Instructions	Radio Telephone Dial Access Electronic blackboard Slow-scan television Facsimile	Pre-produced and edited programs Lectures, seminars and discussions Retrieval of audio information Transmission of documents, still images and hand-written information Audio conferencing
	COMPUTER	Minicomputers Personal computers	Computer-assisted instruction Computer-managed instruction Computer-aided testing Problem solving	Central computers Remote terminals Time-shared computing	Information retrieval Computer-assisted instruction Computer-managed instruction Computer-aided testing Problem solving Electronic message delivery Computer conferencing
	VIDEO	Videotape Videodisc	Stored lectures and presentations Interactive instructional programs	Instructional Television Fixed Service (ITFS) Cable Satellites Broadcast television	Pre-produced and edited programs Lectures, seminars and discussions Video conferencing

Fig. 1: CLASSIFICATION OF VARIOUS TECHNOLOGIES USED IN EDUCATION

extensive bibliography prepared for the Subcommittee on Science, Research, and Development of the U.S. House of Representatives (Congressional Research Service, 1971). This view point of the subject is treated by Seibert in another section of this encyclopedia.

AUDIO AND AUDIOGRAPHIC

Speech has been a primary means for instruction throughout all of man's history, achieving some of its most effective use in the gardens of Akademos. In the past one hundred years, as increasing numbers of people were to be educated and teachers had to deal with larger numbers of students, technology advanced. Developments allowed a person's voice to be recorded -- first on records, later on erasable tapes -- for replay at the convenience of the listener, and to be transmitted over distances by radio for one person to address many people or by telephone so that two or a small number of people could carry on a conversation. There is no doubt that speech can be used effectively in education; the only question is how it can be used most effectively.

Radio and Audiotapes

Records and audio tapes have been used for self-study courses since World War II, largely in the teaching of languages, but more recently in a growing number of other areas, particularly continuing education. The media were used to present models of speech, lectures, drill-and-practice routines, and instructions to engage in reading or other exercises. A significant use of audiotapes in altering traditional classroom approaches was made by Samuel Postlethwait in 1961 when he developed the audio-tutorial method for providing remedial instruction for the students in his introductory botony class at Purdue University. The approach has three major components: independent study sessions in which students learn from audiotapes and other media in self-instructional carrels; general assembly sessions that are held regularly and in which students hear guest lecturers, view films or take major examinations; and weekly integrated quiz sessions

in which an instructor deals on a more individualized basis with six to ten students. (Postlethwait et al, 1971) The approach was very successful and has been imitated and adapted in many other subject areas at numerous colleges and universities. A great deal of research has been conducted on the effectiveness of the audio-tutorial approach, with mixed results. Kulik, Kulik and Cohen (1979) have summarized much of the research and conducted a meta-analysis of the results from 48 studies reported by others. Their major conclusions are that this approach has a significant, but small, overall effect on student achievement in college courses, and it has no significant effect on student course evaluations or course completions. Since this approach is no less effective than traditional methods, it can be used effectively in situations where traditional classroom methods are inappropriate, such as when an instructor is not available or when small numbers of students are to be taught.

Speech is an effective medium of instruction even when it is transmitted over distance to learners who are not in physical contact with the instructor. Almost 50 years of research (Cohen, 1937; Woefel and Tyler, 1945) show that radio, a medium that first was applied to education in the 1920's and whose use continues today, can be effective in instruction. Lumley (1933) studied high school students who were taught foreign languages with the aid of radio, and found that students who heard the radio lessons had improved pronunciation over those students who did not hear the radio. The University of Wisconsin Research Project in School Broadcasting (Radio in the classroom, 1942) undertook an extensive two-year study of the use of radio broadcasts at several grade levels in seven subject areas. In controlled comparisons, there were no significant differences noted between students in the control and experimental groups, in most subjects. In music, however, the radio classes did significantly better in recognizing note values, reading at sight and in recognizing, rhythms, but showed no significant differences in taking musical dictation. The Japan Broadcasting Company (The effects of educational radio, 1956) used radio to teach English to students in the 3rd, 5th and 7th grades, and the radio classes experienced learning gains in every case at or above the level of conventionally

taught classes. Constantine (1964) studied students who were taught science by radio in elementary schools, and found that the students gained on the average 14 months in one school year on standardized tests of scientific information, and 15 months on standardized tests of work study skills.

In many ways, radio has been a forgotten medium with respect to instruction. Although there are many fine educational programs broadcast on radio today, the amount of time devoted to instruction in over-the-air broadcasting is very small. In an analysis of public radio programming, Katzman and Katzman (1978) found that of the 199 public radio stations which qualified for assistance from the Corporation for Public Broadcasting, 178 of them broadcast over 1.2 million hours of material during fiscal year 1978, for an average of 18 hours, 33 minutes per station per day. Instructional programming, however, constituted only 1.2% of the hours broadcast for grades K through 12; 0.2% for college credit instruction; 1.2% for continuing education; and 0.6% for other categories of instruction. Since there are about 900 public radio stations in the United States, the majority of which are small or of limited operation and do not qualify for CPB-support, it is possible that the figures for the amount of instruction provided by the CPB-supported stations may not be representative of the total group. More accurate figures, however, do not exist.

Telephone

The use of the telephone in instruction is more recent than that of radio, and few statistically significant studies of its effectiveness have been conducted. Conceptually, however, the telephone should be at least as effective, if not more so, since it is more versatile than radio and allows interactive as well as one-way communications. There presently are several telephone-based educational delivery systems in use, with the largest operated by the University of Wisconsin-Extension. In existence since 1965, this system reaches tens of thousands of students located at 200 sites around the state of Wisconsin each year. Telephone systems are most

effective in tasks that stress an exchange of information, a generation of problem solutions, or straightforward administrative agendas. They are less appropriate for tasks that require interpersonal aspects, such as getting to know someone or appreciating nonverbal reactions to others.

The telephone, however, does not have to be used only for conversations or for audio presentations. It also is possible to transmit visual information from one location to another using voice-grade telephone lines or other narrowband communications channels. There is rapid and continuing technological development going on in this area, referred to as audiographics, so that by the end of the 1980's there should be a large number of products with different capabilities available from many manufacturers which can be used in education. Audiographic equipment can be categorized into three divisions, which are not mutually exclusive. These are telewriter devices, compressed video or slow-scan TV systems, and facsimile equipment.

Telewriters

Telewriter systems link two mechanical or a mechanical with an electronic devise to transmit hand-written information. The material may be entered using electronic pens, tablets, blackboards, or video writers. Although telewriting devices differ in specifics, they are based on a common principle that visual information can be transformed into electronic signals by writing on a special conductive surface. Within a defined area, the location of a writing implement can be determined by sensing its horizontal and vertical positions as a point on a conductive grid. This information is used to generate an appropriate electrical signal, which is transmitted over a phone line and used at the receiving end to position a mechanical pen or more often the electron beam of a TV monitor. As someone draws or writes on the sending device, the points are transmitted to the receiver and a corresponding line or word is traced to reproduce the given information.

The "Electrowriter", a device using an electro-mechanical pen and initially

marketed in the early 1960's, was one of the first telewriters. Free-hand graphics and script are written on a paper-covered paten with a special pen. The pen produces electronic signals that are processed and transmitted to any number of remote locations via telephone lines, where they direct a mechanical pen that reproduces the original information on paper or acetate film. The paper is usually roll fed and can be advanced by sender.

A more recent and more sophisticated device, and one better suited to the traditional classroom format, is the electronic blackboard. The primary component is a specially designed surface that in appearance is similar to an easel-mounted blackboard. The writing surface is used like an ordinary blackboard, with the instructor writing on it with chalk and erasing either part or all of the drawings with an ordinary blackboard eraser. The chalk strokes are converted into electronic signals that can be transmitted on one or more remote locations where they are reproduced on a TV monitor. Using a storage tube memory at the receiving site, the graphics are displayed on the monitor as white lines on a black background for easy viewing in ordinary room light, and remain until erased. If more writing surface is required two or three blackboards can be connected using the same phone lines. In addition, it is possible to connect a hard-copy printer to a receiving unit to obtain paper copies of the graphics, use a stereo tape recorder to record the voice and graphics for later replay, and connect audio conferences devices for large group interaction. A one-year trail of the system was conducted by the University of Illinois, using three blackboards located at the Urbana campus, to teach eight graduate-level engineering courses in each of two semesters. Reports are that the system was found acceptable by both the students and instructors, and that there was no perceptable difference in grade-measured performance between the students at the remote locations and the students at the originating site. If anything, the quality was believed to have improved because the teachers were more deliberate in their presentations. (Shah and Torok, 1979)

Slow-Scan TV

A second major class of telewriting devices is termed slow-scan television (SSTV). These devices appear to have great potential for educational and other telecommunications applications in which the full pictorial capability of ordinary television, other than full motion, is desired. The relationship between the transmission of full-motion video and SSTV is similar to that of sending water from one location to another through a pipe. In order to get a certain amount of water at the receiving location, either a large diameter pipe can be used for a short period of time, or a small diameter one can be used for a longer period of time. The same amount of water can be sent, but the time to transmit it will vary inversely with the diameter of the pipe. In SSTV, telephone lines (which have about 1/3000th the capacity of a conventional TV channel) require 100 seconds or so to send a single picture, rather than being able to transmit 30 images per second as in the more familiar full motion, broadcast TV. A current large-scale application of SSTV is a 24-hour-a-day news program initiated by United Press International that uses satellite and cable system for delivery to homes. UPI employs a single frame "newspaper" photo format to accompany the voice of a narrator, a format that could satisfy certain educational requirements.

Facsimile

The third category of telewriters is facsimile. This type of equipment allows documents to be transmitted over long distances and be reproduced on paper in a matter of minutes or seconds. The material may be printed, written, drawn or in the form of computer printouts. A facsimile system consists of two machines (transceivers) connected through voice-grade telephone lines. Input documents are scanned by an optical device in a line-by-line fashion. The dark and light areas are sensed and converted into electrical signals that are transmitted to the receiver which uses this information in synchronism with the input scanner to reproduce the original image. Although newspapers were using facsimile devices in the 1920's,

the business market for them did not materialize until the 1960's. Since then major improvements have been made in facsimile systems, especially with the advent of microelectronics and digital signal processing.

Educational Telephone Networks

The University of Wisconsin has created several state-wide networks, using the telephone system, to provide a variety of educational services to diverse client groups. More than any other organization, the University has demonstrated with large-scale operating programs that the telephone can be an effective and affordable means for prividing continuing, professional and adult education.

An Educational Telephone Network (ETN) delivers credit, continuing education and public service programs to learners in their home communities. It is a dedicated network that links about 200 study centers in the state with extension officers, campus centers, hospitals, libraries and other sites as necessary. Learners at the sites hear the instructor through a speaker and use individual microphones to ask questions or make comments. ETN programs enroll about 32,000 learners a year in about 260 offerings.

The Statewide Extension Education Network (SEEN) is also a two-way interactive audio system that delivers education to 23 Wisconsin communities. Its distinctive feature is the ability to transmit line drawn graphic material in real time over telephone lines and display it at the receiving site on a television monitor. SEEN also is experimenting with the use of slow-scan television to augment the line graphics capability.

An Administrative Teleconference Network (ATN) uses the audio portion of SEEN during unscheduled network time to interconnect the 27 campuses and administrative offices of the university system for a variety of purposes.

A Meet-Me Teleconference System, using the same two-way telephone links, connected 20 locations in 1980 for 256 sessions of faculty, staff and committee meetings,

planning sessions, student conferencees, and other activities.

A dial-access system provides telephone access for anyone in the state to a pre-recorded library of more than 1,000 audio tapes on a broad range of topics of educational and consumer interests. In 1980, more than 90,000 requests were received. The system is semi-automated at present. The caller gives the answering operator the number of the tape he wishes to hear; the tape is accessed and played for the caller. The Wisconsin system is in the process of converting to an automated system in which the caller's voice activates a microprocessor unit which asks the number of the tape being requested, recognizes the numbers given, and retrieves and plays the tape for the caller. Each module in the system (for health, agriculture, commerce, law, etc.) can store up to 1040 tapes which can be accessed simultaneously through 20 telephone lines. The University estimates that the amortized cost to purchase and record a tape is 3 to 4 cents per call.

COMPUTERS

The earliest work in applying computers to education began in the late 1950's, with activities at IBM to develop the COURSEWRITER language and at the University of Illinois where initial work began on the PLATO system. Since then there has been a great deal of effort in applying computers to education, although the intensity has varied over time. While the use of a computer for direct instructional presentations has not yet fulfilled its total potential, computers have become important and essential elements in education.

Expenditures

In the area of higher education alone, the total expenditures for computing have been estimated to be $1.2 billion in 1980, which far surpasses the $51 million expended in 1963 and the $472 million in 1970. (Hamblen and Baird, 1979) It is estimated that currently 2,163 institutions of higher education, with a combined enrollment of almost 10 million people, provide students access to computers, although it does not follow that all students attending those institutions are exposed to computers. In 1976-77, funds for administrative uses of computers

were about 45% of the total expenditures, for research about 22%, and for instruction about 27%. (Molnar, 1980).

A significant impetus for computing in education has come from the federal government, although that influence has declined significantly in recent years. In 1965, 36% of the funding for computers came from the federal government. By 1970, the federal share had declined to 17%, and today it is estimated to be much lower. The states and the institutions themselves provide the major sources of funding for computing in colleges and universities, while local sources provide the greatest portion of the costs at the elementary and secondary education levels. (Molnar, 1977). In the area of instructional applications, the civilian agencies of the federal government expended about $7.5 million in 1966, which rose to a high of $37.4 million by 1969, and then declined to $6.6 million in 1971, a level from which it has varied very little, reaching a low of $3.4 million in 1977. (Computers and the learning society, 1978, a).

Trends in Computer Hardware.

Two trends are taking place in the development of computers. One is the development of larger and larger machines, often interconnected or accessed through telecommunications. The other is the development of smaller and smaller computers having greater and greater capacities for less and less cost. Both trends have affected education, the first primarily in research and administrative applications, the second in instructional applications. A major force affecting the widespread use of computers has been the developments in semiconductor electronic that have allowed the production of semiconductor chips, each about two-tenths of an inch on a side, with processing capabilities that have doubled every 14 to 15 months, since the mid-1960's. The first chips each contined a single electronic element. Today on a chip of the same size, and at approximately the same cost, over 64,000 elements are packaged, and the growth in capability is continuing. These developments have made possible the personal computer and the widespread availability of handheld calculators. Tens of

millions of calculators have been sold, some of which are now available at under $10. Handheld instructional devices that provide drill and practice exercises in arithmetic and spelling are available for $15 to $25, with units that simulate a human voice priced at about $60. Home computers, containing a video display, keyboard, processor and sizeable memory are available for under $500, and have enough capability to do limited computer assisted instructional activities, carry out computations, create small files of information, and play interactive games. In 1979, the annual personal computer sales, mainly to professionals, businessmen and hobbists for their personal use, was estimated to be about 350,000 units with a value of $500 million. (LeBoss, 1980)

Availability of Computers

The Minnesota Educational Computing Consortium (MECC) recently purchased 700 microcomputers, 555 of which were installed in elementary and secondary schools, and the remainder in institutions of higher education. Eighty villages in Alaska have purchased microcomputers in order to provide village children with a core curriculum at the 9th and 10th grade levels. This curriculum will shortly be made available to every school in the state that wishes to use it and purchase the necessary computers. In both states, a large number of subject areas are available for study by computer. The State University of New York at Stony Brook has established a National Coordinating Center for Curriculum Development, which is attempting to motivate students through the use of computers into pursuing engineering careers. Students have an opportunity to check out microcomputers overnight or to use them on weekends at youth centers. Papert (1973) has been working with elementary school children to teach computer-based problem solving in mathematics, physics, biology and music, using a variety of innovative approaches, including a "slot machine" that allows students to select a program by choosing a card having functions pictorially displayed on it from a set of cards, and a computer-controlled motor-driven "turtle" that allows students to draw figures or explore millions

concepts in science. Using more sophisticated computing devices, Bork (1975; 1977) has investigated the use of graphics in computer-based instruction and the use of visual information as an alternative to alpha-numeric tools. Dwyer (1974; 1977) has developed a computer-based mathematics laboratory for secondary school students that creates a rich learning environment, in which a student first works in a dual training mode with a teacher and then in a creative way in a solo phase.

Computers also are used extensively to provide certain types of training and education in several large corporations, in the military and in federal government agencies. IMB, for example, provides over 800,000 student-hours a year or about 40% of the training of its 18,000 customer engineers and program support personnel through computer terminals at 160 branch offices located throughout the U.S. United Airlines now is providing a significant amount of the training for the several hundred new pilots it hires each year by computer instructional methods, and expects to conduct its entire pilot transition training program for the Boeing 767 using a computer-based system to manage the complete course from the acquisition of knowledge through exercises and practice in an airplane simulator. At Lowry Technical Training Center, the U.S. Air Force provides training and training management for up to 2,100 students per day in several courses. In addition, the Boeing Company, the Internal Revenue Service, the Civil Service Commission, the U.S. Army, the U.S. Navy, the Federal Aviation Administration and others are expending large amounts of money to offer and investigate computer-based instructional methods.

Computer-Based Instruction

Computer-based instruction includes a broad range of application that can be divided into the two general categories of direct instruction and instructional management. The former is usually referred to as computer-assisted instruction (CAI), and includes such activities as drill-and-practice, tutoring, simulations and gaming, inquiry and dialog, information retrieval, and problem solving. The second category, often termed computer-managed instruction (CMI), includes instructional support

functions such as testing, prescribing, record-keeping, scheduling, monitoring, and time and resource management. The hardware for both categories of applications are the same.

Perhaps the largest system combining both computer-assisted and computer-managed instruction is at the Lowry Technical Training Center. With 50 interactive student terminals and 10 management terminals, supported by a high level computer language called CAMIL, the system offers a rich variety of information to students, instructors and training managers. For students, the system: (1) scores tests; (2) lists objectives not mastered; (3) makes individualized assignments, including remediation by objective; (4) assigns and locates resources required to accomplish an assignment; (5) provides target completion times and rates of progress; and (6) selects and assigns alternative lesson treatments. A limited number of lessons are presented via CAI, with on-line testing imbedded within the module.

For instructors, the system: (1) flags students with entry deficiencies and proficiencies; (2) scores tests by objective, critical "must pass" items and overall percentage correct; (3) insures that lessons are taken in proper sequence; (4) tracks completed lessons; (5) tracks alternative modules and assigns students accordingly; (6) provides random assignment of lesson and block tests; (7) furnishes daily learning center rosters that flag students with deficiencies with respect to the rate of progress and indicates absences; (8) maintains a resource inventory in real time; (9) provides reports on individual student performance; and (10) allows recall of student data profiles for use in counseling and student progress management.

In addition, training managers and course designers are furnished information that can be used to: (1) standardize the course presentation; (2) balance utilization of training resources, such as student loads across shifts, learning centers and curricula; (3) determine times to complete instructional segments; (4) provide

test security through on-line testing and random assignment of tests; (5) describe characteristics of students in the course through pre-assessment test data; (6) report student attitudes toward the course; and (7) provide performance summaries of item analysis data for evaluating and reviewing course materials and tests.(Yasutake and Stobie, 1979) Computer-assisted and computer-managed instructional systems, with a large variety of services, do not necessarily require large systems, however, and it is possible to implement these types of systems on microcomputers. (Milner, 1980)

Course Materials

Computers used for instruction, however, are no better than the material they contain. While there have been great gains in computer hardware, with mass production driving down costs while maintaining high quality, similar gains have not occured in the software (or courseware) aspects. A distributor of course material for microprocessors has stated that buyers should be careful and selective, for 95% of all the programs carried should never have been offered for sale. (Purser, n.d) In an effort to assist the educator, the Northwest Regional Educational Laboratory has established a national clearinghouse for microcomputer-based instructional materials designed for use in K-12. (MicroSIFT News, 1980) The lab's approach is to collect and evaluate instructional programs, and to disseminate information about them to educators. CONDUIT is non-profit, university consortium that disseminates computer-based educational programs, including microcomputer materials developed for use at the post-secondary level. (CONDUIT) These two efforts are important because of their quality-assurance aspects and because of the potential wide-spread use of these materials in the future, which can be stimulated by declining costs. One publishing firm had advertised a mathematics series on a microcomputer for grades 1-6 for 10 cents per student-hour. (Mathematics series) The Dallas Independent School District plans to offer bilingual instruction for 50 cents per student-hour. (Dooley, 1978)

Evaluations of Computer-Based Instruction

Evaluation studies of computer-based instruction can be categorized into two groups. First, there are the large-scale evaluations of the major projects, such as the development of PLATO, TICCIT and the remedial drill-and-practice materials of the Computer Curriculum Corporation, each of which has received from $2 to $20 million in research and development funding. Then there are the shorter, less extensive studies of other efforts.

PLATO utilizes a large computer to support 400-500 terminals distributed throughout the country and connected by telephone lines. Many programs are stored centrally and delivered to the remote sites that require them. Control Data Corporation, which now markets PLATO, has made it available from about 130 centers throughout the country to minimize communications costs. A large-scale evaluation of the PLATO system by Educational Testing Service has found that there was no significant difference in student achievement or in attrition rates between PLATO and non-PLATO taught classes, but that both students and teachers liked the idea of using PLATO. (Murphy and Appel, 1977). Although the evaluations may not be as positive as one would like, the use of the PLATO system is increasing. The University of Delaware, for instance, installed a PLATO system in 1975, and by the spring of 1980 faculty members, students, and programmers were spending over 200,000 hours annually developing programs in over 80 subject areas, using the University's 132 terminals on-campus, and with support also given to another 70 terminals off campus. (Hofstetter, 1980) Further, Control Data Corporation, which has made a sizeable corporate investment in the PLATO hardware using central computers and in courses for it, has introduced a version that operates on microcomputers.

TICCIT uses stand alone mini-computers to serve terminals that incorporate standard TV sets, with the courses developed by teams of instructional developers After Educational Testing Service evaluated the effectiveness of three courses, developed at a cost of almost $1.9 million each, in three post-secondary institutions, it found that TICCIT-taught students scored on the average 5% higher

on final examinations, but had markedly lower completion rates and felt more ignored as individuals than students in teacher-lead courses. (Alderman, 1978).

Crandall (Computers and the learning society, 1978, b) report that the students at the 4-6 grade levels who used computer-based remedial drill and practice materials developed by the Computer Curriculum Corporation performed 30 percentile points higher in mathematics and 13 percential points higher in reading, than those who did not use the materials, and exhibited less truancy, tardiness and vandalism.

Very few programs have been run as extensively or with as much support as these three. In evaluating the effectiveness of other efforts, Kulik, Kulik and Cohen (1980) reviewed the results of 59 studies of computer-based education using meta-analysis techniques, and found that at the college level the computer made a small but significant contribution to the effectiveness of the teaching of students of all aptitude levels, raising students scores on examinations by about one-quarter of a standard deviation; and had a small but positive effect on the attitudes of students toward the instruction they received and toward the subject matter. At the elementary school level, the results were even more dramatically in favor of computer-based education used in a supplementary fashion, as the studies of Edwards et al (1975) and Vinsonhaler and Bass (1972) have shown. A meta-analysis of evaluations of the effectiveness of computer-based teaching at the elementary level conducted by Hartley (1977) showed gains of at least one-half of a standard deviation in favor of computer-supplemented teaching of children.

In all of the evaluations of computer-based education, numerous effects can be introduced and so the evaluators must be cautious. Anastasio (Information technology in education, 1980) stated that the results of many of the evaluations that have been conducted could have been determined simply by reviewing the contens of the treatment curriculum, of the comparison curriculum and of the test used. He further states that in the evaluation of the remedial mathematics programs

discuss above, children may have learned test-taking skills more than mathematics, since CAI-taught students continued to make the same frequency of errors as did non-CAI-taught student students

Computer-Assisted Testing

Computers also are playing an increasing role in the administering of tests to students. Efforts to develop computer-assisted test have followed three approaches: the construction of tests from computer-based item pools of varying complexity; the administering of tests; and the tailoring of tests to match the ability of the test taker. The National Association of Security Dealers, for example, currently offers 12 different qualifications tests for stock brokers and managers, at times they request, by computer at 69 sites around the country. In each of the 12 subject areas, the computer creates a test for the individual by selecting items from a group of 200-2,000 items stored in a data bank, offers and grades the test, and then reports the results to appropriate officials in state agencies and security firms. (Milner, 1979).

While the National Association of Security Dealers relies on large-scale computers to support remote terminal for testing, Educational Testing Service is carrying out a variety of research activities using handheld calculators and microcomputers to enhance the testing situation. They particulaly are investigating how computers can simultaneously be used to test a student's ability and as an instructional device, by providing the student with encouragement when a testing item is correctly answered or giving hints and allowing the student to try again when errors are made. (Technology and education, 1980) These are new applications, but appear to have the potential to grow significantly in the next decade.

In addition to the applications already described, terminals interconnected by telecommunications can also be used to create messages and deliver them electronically. Electronic mail is a computerized way of creating, editing, filing, storing and

distributing to one or more locations any information that can be entered into a computer. This can include course schedules, teaching tips, administrative announcements, requests for information, tabular material and any other data and information necessary to conduct an effective educational enterprise. Electronic mail systems are easy to operate, using language that is similar to English commands. Sent via telecommunications to a central computer, the information can be made available to all or a selected number of persons. All messages are secure and only will be displayed to someone entering the correct code for his or her "mail box."

In Alaska, an electronic mail system has been installed as part of an educational delivery system. It links together, via satellite and computer, all 52 school districts in the state, several regional centers and the State Department of Education. Although telephone service exists in all of these locations, last year 350 teachers and administrators sent over 10,000 messages through electronic mail. (Expanding educational opportunities, 1980).

Computer Conferencing

An application that combines the characteristics of electronic mail with those of audio conferencing is computer conferencing. The participants in a computer conference, using a computer terminal, can ask questions of other participants answer queries, make comments to a few or all participants or ask for a recall and possibly an analysis of previously provided information. Similar to an audio teleconference, a computer conference can involve two to a large number of partcipants located at many sites, each of which is connected to the computer through a communications link. The participants all may be on line simultaneously or, since the messages are stored in a computer, the conferees can participate at different times over an extended period to suit their schedules. This approach might be particularly useful for a course manager allowing him or her to conduct a conference with a large number of teacher-leaders, who are at many locations in the field. In addition to providing flexibility in times to participate, the computer can accommodate responses from large numbers of conferees to a given question from the course manager and can

even analyze the responses to determine common positions.

VIDEO

The use of television in education has grown sharply in the United States in recent years. This has been stimulated by the development of public broadcasting, by the increasing availability of communications satellites and other communications media for educational applications, and by the interest of colleges and universities to explore and develop new markets in a period when the traditional college age is declining.

Broadcast Television

Although television has been utilized in education for 30 years, it received a significant impetus in 1967 with the passage of the Public Broadcasting Act. This legislation and the subsequent 1975 Public Broadcasting Act and the 1978 Public Telecommunications Financing Act ensured federal support for public broadcasting through the Corporation for Public Broadcasting (CPB). Since the beginning of federal involvement, public broadcasting has grown substantially. The number of public television stations increased from 126 in 1967 to 290 in 1980, and they now provide coverage to 90 percent of the American TV households. In March 1980, over 68 percent of the nation's TV households tuned to at least one program on public television. The average annual broadcast hours per station was 4,894 hours in FY 1979, an increase of 26 percent over FY 1974, with more than 1,000 instructional series at the K-12 levels broadcast on one or more public television stations, and with 137 of these series carried by ten or more licensees. Instructional television for use in the schools comprised 14.8 percent of the total hours broadcast, while broadcasts of Sesame Street and The Electric Company for home viewing totalled to another 14.5 percent (Lee, 1981).

Educational uses of broadcast television began a new phase in reaching mass audiences when Sesame Street was first put on the air in 1971. Developed by the Children's Television Workshop, with funding primarily from the U.S. Office of

Education and the Corporation for Public Broadcasting, its purpose is to teach youngsters, 3 to 5 years of age, basic skills such as recognition of letters of the alphabet and number concepts. The programs have been developed using a combination of sound pedagogical approaches and the techniques of entertainment television, together with formative research and evaluation. The program was immediate success. The show, which consists of 130 one-hour programs that are partially revised each year, is viewed by about 8 to 9 million children annually. It currently is carried by 97% of the public television stations in the United States, as well as a number of commercial stations in areas where there is no public television, and reaches 85% of the 3- to 5- year old children in inner cities. In addition, it is shown in modified versions in 40 foreign countries.

Based on the success and approach of Sesame Street, CTW introduced The Electric Company in 1973, to teach basic concepts and skills in reading. Today, about 6 million viewers including some 2.5 million children in grades 1-6 watch the program in school. It is seen in about one-half of the nation's homes where there are children under the age of six, and by at least some children in about 30% of the country's elementary schools. In 1980, 3-2-1 Contact, a series designed to teach basic skills in science, was aired and in that first year was seen by 4 to 5 million children.

In the late 1970's public television stations also broadcast a series of programs that included The Ascent of Man, The Adams Chronicles, Classic Theatre: The Humanities in Drama, and others. While these programs were designed for general audience viewing, ancillary study materials were developed that allowed interested colleges to award credit for the successful completion of courses "wrapped around" these shows. It is estimated that more than 600 American colleges now provide credit for courses delivered to viewers by cable, satellite, commercial and public TV. (Luskin, 1981). As part of its Educational Programming Service (PTV-3), the Public Broadcast Service (PBS) is broadcasting college credit courses,

informal learning series, and professional and career training programs for adult learners. A college or university, which chooses to award grades and credit for PTV-3 courses, selects from a wide variety of available courses those that it wishes to offer, and then works with its local public television station to develop a broadcast schedule that meets local needs.

The University of Mid-America, a consortium of 11 state universities has been producing and offering courses by television and other media for most of the 1970's, and now is planning for a nationwide American Open University that would offer both graduate and undergraduate courses through television. The National University Consortium for Telecommunications has begun to offer courses for undergraduate degrees via television and other non-traditional delivery systems. The Central Education Network, composed of the public television stations in 10 midwestern states, together with representatives from institutions of higher education, has formed a postsecondary council to determine the needs for telecommunications at the 821 colleges and universities in its area, and to obtain savings by group purchases of telecourses and equipment. (Scully, 1980) Recognizing the role that television has and can play in American education, Walter H. Annenberg, in early 1981, donated $150 million over a 15-year period to the Corporation for Public Broadcasting to support the production of high quality, college-level courses for distribution through existing and developing telecommunications systems. (Scully, 1981).

Instructional Television Fixed Service Systems

Broadcast television is used most effectively when it is necessary to reach large numbers of people dispersed over relatively broad areas, since it is a means for mass distribution. When small or localized audiences are to be reached, other means of delivery, such as Instructional Television Fixed Service (ITFS), are more appropriate. ITFS was established by the Federal Communications Commission in 1963 as a "point-to-points" distribution system for transmitting as many as four channels of black-and-white or color TV to predetermined receiving sites, such as schools, colleges, hospitals or industrial plants, equipped with special receiving antennas.

There currently are more than 100 licensees holding 200 licenses for more than 500 ITFS channels. The largest consortium of ITFS users in the country is the Catholic Television Network, which has affiliates located from Boston and New York on the east coast to Los Angeles and San Francisco on the west coast. The Long Island and Brooklyn affiliates each serve over 200,000 students with instructional programming, while the Chicago affiliate reaches over 400 locations in that area. On the average, each of the Network's affiliates serves over 80,000 students with about of 160 hours of broadcasts per week. (Curtis, 1980)

While the most extensive use of ITFS has been by parochial school systems for the delivery of classroom television for elementary and secondary classes, it is used regularly by institutions of higher education to provide graduate education to engineers and other professionals located at plant and office sites, as well as for meeting a wide variety of other educational needs. The Center for Excellence in Williamsburg, Virginia has served the peninsular area with improved educational services for handicapped individuals, and is expanding its system into a multi-channel, multi-service, two-way public telecommunications network. (Roth, 1980) The South Carolina Educational Television Commission is establishing a 4-channel ITFS system to improve basic skills for school children, provide adult education, serve inservice needs of school staffs, and meet communications needs of the residents of a rural county. Stanford University and the University of Southern California are utilizing an ITFS system with interactive "talkback" to provide a variety of educational courses for engineers in many high technology companies in the Palo Alto area. In the northeastern part of its state, California State University at Chico is extending its ITFS network to meet the higher educational needs of a widely distributed, rural population of about 511,000 persons spread over 12 counties. The development of these and similar systems to serve a wide variety of local needs are significant because they occurred with little or no federal support. Funds to

construct and operate these system have come from administrators who chose ITFS over other competing demands.

Satellites and Cable Systems

The recent availability of high powered satellites that operate into moderate to low cost receivers has stimulated an even greater interest in the use of television for education. All public television stations are now interconnected by satellite, through the Public Broadcast Service, so that programs can be distributed rapidly and reliably. In addition, large numbers of cable systems have added satellite antennas to their systems to receive, from a variety of distribution services, programming that they make available to their subscribers. The number of such cable systems has increased from about 200 in 1978 to more than 3,000 in 1981 to a projected 7,500 in 1983. Several organizations have been created to take advantage of this new capability by operating satellite-based delivery systems for education. The Appalachian Community Service Network is a good example. The Network currently offers 65 hours per week of college courses, adult education programs, seminars and community interest programming to over half-a-million homes throughout the nation. Originating in Lexington, Kentucky, the programs are transmitted via an orbiting satellite and received by a large number of cable systems, which in turn make it available to their subscribers in homes, schools, hospitals and community centers. At current growth rates, the Network should reach over 2 million people by the end of 1981. More than 50 colleges and universities offer graduate-level credit for courses taken through the Appalachian network.

The Association for Media-Based Continuing Education for Engineers (AMCEE) is investigating the use of satellites to distribute videotaped course to engineers throughout the nation. AMCEE already has offered a course in engineering economics via the Appalachia network, for which graduate-level credit was granted to those persons who enrolled in one of the many participating colleges or universities and successfully completed the course. The American Educational Television

Television Network, a public service pay TV network broadcasting adult education via satellite through cable systems, has been designed to assist members of professional associations and employee organizations in meeting state licensing and college credit requirements. Formed in June 1979, the network is focusing its programming and marketing efforts to meet the needs of dentists, physicians, nurses, lawyers, engineers, accountants, social workers, pharmacists and many other professional groups. These occurrences clearly show that satellites are becoming a more common means of distributing education via television to those persons who need it, regardless of their locations.

Satellites scheduled to be launched in the next several years will be even more powerful than present ones, and will be capable of broadcasting materials directly to homes or schools. Comsat, which filed a petition with the Federal Communications Commission in 1980, expects to invest $700 million to design and launch a 3-channel, direct broadcast system of six satellites, and to manufacture millions of small antennas, $2\frac{1}{2}$ feet in diameter, for sale to the public. It expects that the antennas will sell for about $100 to a projected market of 35 million homes. (Comsat sets DBS proposals, 1981) Although this system is not designed for education, its ability to broadcast directly into homes and schools, as well as the fact that more than 100 TV channels will be available on satellites within the next few years, provides opportunities for one or more organizations to serve education through this medium.

Video Recording Media

While television is a means for transmitting video program over large distances, other, less expensive media have been used since the early part of this century to record and distribute full-motion visual information for education. Experiments with instructional films were conducted as early as 1918. (Hoban and VanOrmer, 1950; Greenhill, 1967). As new technologies for pre-recording materials developed, they also were incorporated into education. Added to film as a means for delivery were videotape and videocassettes, and most recently videodiscs.

Videotaped courses are used extensively in continuing engineering education. Twenty-one engineering colleges and universities have joined together under Association for Media-Based Continuing Education for Engineers, a non-profit corporation, to produce and distribute videotapes of courses, seminars, short-courses and symposia for off-campus use. The guides and/or textbooks, are of two types. One type corresponds to regulary scheduled undergraduate and graduate courses given to on-campus students. The "candid classroom" is recorded, allowing the viewer to hear and see everything that the on-campus student does. The viewer also receives the same class handouts and may participate in tests and receive credit for successfully completing the course. The second type consists of courses that have been specially prepared in TV studios under broadcast quality conditions, and which are not tied to a university's scheduled on-campus offerings. (AMCEE, n.d.)

Many of the University of Mid-America programs that have been designed for broadcast by television also are available on videocassettes and film. The programs are generally supported by a textbook, study-aids such as maps and audio tapes, and a study guide that integrates all the learning components. These materials which are classified into fourteen subject areas are used for enrichment or supplementary activities by secondary schools, libraries, museums, businesses and universities. (Catalog '81, 1981) Other major distributors of films and/or videotapes include the Great Plains National Instructional Television Library located in Lincoln, Nebraska, and the Agency for Instructional Television, in Bloomington, Indiana. In addition to educational institutions, many large corporations produce and use videotapes for in-house education and training of technical, managerial and other professional personnel.

The videodisc is the most recent of the media for storing and playing video materials. A disc, which is similar in appearance to a long-playing record, is about 12-inches in diameter and can store up to 54,000 individual frames or pictures, or

30 to 60 minutes of full-motion video on each side. It is viewed by using a player, which is about the size of a portable phonograph, connected to an ordinary TV set. A disc has two tracks that allow narration in two languages to accompany the visuals, separate narrative information for two levels of background knowledge of the students, or music in stereo. In addition, a disc can be used to store about 10 billion bits of information, which is about five times the amount of information that is necessary to encode the entire Encyclopaedia Britannica, or enough to store the contents of about 300 books on each side of the disc.

No single standard exists as yet for videodiscs, so that several incompatible versions are being developed and marketed. Some are more suitable for educational purposes than others. A very popular type that is widely marketed for home entertainment is a capacitive disc. Although the player is lower in cost than the players for other types of discs, the capacitive disc can play only full-motion sequences. Optical or laser-read discs, in contrast, can have the frames individually coded and displayed so that a single side of the disc can store 54,000 slides, one-half hour of continuous motion pictures, or a combination of the two. It also is possible to use the disc in a dynamically-programmed format for stand-alone use or in conjunction with an external computer in an interactive mode. The interactive videodisc system can be used in instruction in five nondiscrete approaches. It may be used as an instructor-controlled support mechanism for interactive or passive group presentations. It can be used for individualized stand-alone presentations as: a non-programmed device; a dynamically programmed devise in which the program is entered from a remote keypad; or a device in which the controlling program is stored on the disc. In addition, the disc can be used as an ancillary device to a computer external to the one contained within the disc player. (Long, 1981)

A number of groups are designing and evaluating courses for presentation by videodiscs in combination with microcomputers. In these early stages of application

the purposes of the efforts are to determine the instructional strategies employed by teachers who use videodiscs, determine cost-efficient ways to develop quality materials, and assess the attitudes of teachers toward the equipment and the materials. Among the organization doing this type of work are the videodisc design/production group at KUON-TV/University of Nebraska-Lincoln (Daynes, Brown and Newman, 1981), WICAT (Heuston, 1977), and the Minnesota Educational Computing Consortium.

In addition, several large corporations are using videodiscs for education and training purposes. One of the most extensive applications for customer education is by IBM, which has established over 36 Guided Learning Centers around the country to train customers of small business systems about the equipment they purchase. Each center, which is equipped with three videodisc players, remote control units, TV monitors, audio cassette recorders and surrogate computer terminals for completing student exercises, can accommodate 16 students simultaneously. The company has about 20 training programs, which vary in lenth from one to five days, on videodiscs. In 1980, the first year of operation of the centers, 21,000 customers completed slightly over 40,000 student-days of instruction. (Stegmann, 1980; How IBM uses videodiscs, 1981)

Evaluation Results

The use of television in education has been well researched with studies ranging from the evaluation of control and experimental groups in tightly controlled classroom situations to studies of students learning at home and in normal class setting Ball and Bogatz (1970) reported the results of learning measures from the first year of Sesame Street based on a large sample of children in four geographic areas of the United States. They found that the program benefited children from ghetto communities, middle class suburbs and isolated rural areas in teaching them the functions of body parts, and in matching and relational terms, and that among all groups the amount of learning that occurred was directly related to the amount of viewing by the children. In a follow-up study the next year, Bogatz and Ball,(1971) showed some of the subtle differences that can occur in teaching by television. Sesame Street had a noticeable

effect on children in teaching them to name letters, but no effect on alphabet recitation; had an effect on teaching them to match by form, but none in matching by position. A similar series of evaluations of The Electric Company (Ball and Bogatz, 1972; Ball, Bogatz, Kazarow and Rubin, 1974) found that in-school viewing by children in the first and second grades yielded significant gains across the full spectrum of the program's curriculum goals; at the first-grade level, parents of viewing children regarded their children as better readers than parents of non-viewing children; and there seemed to be a long-term gain as children who watched the program for two years did no better than those who watched it for one year. Herriott and Liebert (1972) surveyed the teachers of the children who watched The Electric Company in school and found that about 80% of the teachers surveyed noted some gains in specific reading skills of the children who watched the series; about 24% noted a great increase in reading interest by the students; and 38% reported great improvements in the ability of students to decode words, to spell words (21%), and in basic sight vocabulary (33%). Chu and Schramm (1968) in their major study on learning from television state:

> There can no longer be any doubt that children and adults learn a great amount from instructional television, just as they do from any other experience that can be made to seem relevant to them -- experiences as different as watching someone rotate a hula hoop or reading the encyclopedia. The effectiveness of television has now been demonstrated in well over 100 experiments, and several hundred separate comparisons, performed in many parts of the world, in developing as well as industrialized countries, at every level from pre-school through adult education, and with a great variety of subject matter and method.

Technology developments are resulting in new hardware devices that are providing a plethora of opportunities for improved learning by people at all age levels, both in school and in non-traditional settings. The problems that confront educators are to use these technologies in ways that are effective and affordable, by focusing on the needs of the learner and using the full capabilities of the technology to meet those needs, and to assure that the technology is not misused, creating greater problems than it was meant to solve. (Grayson, 1976a, 1976b, 1978)

REFERENCES

Alderman, D. L. Evaluation of the TICCIT computer-assisted instructional system in the community college (PR-77-10). Princeton, NJ: Educational Testing Service, 1978.

AMCEE videotape courses for engineers, scientists, and technical managers, 1980/1981 catalog. Atlanta, GA: Association for Media-Based Continuing Education for Engineers, Georgia Institute of Technology, n.d.

Ball, S., and Bogatz, G. A. The first year of Sesame Street: An evaluation (PR-70-15). Princeton, NJ: Educational Testing Service, October 1970.

Ball, S., and Bogatz, G. A. Reading with television: An evaluation of The Electric Company (PR-72-2; 2 vols.). Princeton, NJ: Educational Testing Service, February 1972.

Ball, S., Bogatz, G. A., Kazarow, K. M., and Rubin, D. B. Reading with television: A follow-up evaluation of The Electric Company (PR-74-15). Princeton, NJ: Educational Testing Service, June 1974.

Bogatz, G. A., and Ball, S. The second year of Sesame Street: A continuing evaluation (PR-71-21; 2 vols.). Princeton, NJ: Educational Testing Service, November 1971.

Bork, A. The physics computer development project. Irvine, CA: Department of Physics, University of California at Irvine, 1975.

Bork, A. Learning through graphics. In R. J. Seidel (Ed.), Computers and communications: Implications for education. New York: Academic Press, 1977.

The Carnegie Commission on Higher Education. The fourth revolution: Instructional technology in higher education. New York: McGraw-Hill, 1972.

Catalog '81, Videocassettes and films for schools, colleges, libraries and business. Lincoln, N : The University of Mid-America, n.d.

Chu, G. C., and Schramm, W. Learning from television: What the research says. Washington, DC: National Association of Educational Broadcasters, 1968, p. 1.

Cohen, I. D. The relative value of silent reading and radio broadcasting. Unpublished doctoral dissertaion, New York University, 1937.

Computers and the learning society (Report of the Committee on Science and Technology, U.S. House of Representatives). Washington, DC: U.S. Government Printing Office, June 1978, a) p. 9, b) p. 20.

Comsat sets DBS proposal. Satellite communications, February 1981, pp. 32-33.

CONDUIT. A consortium based at the University of Iowa, Iowa City, IO.

Congressional Research Service. New technology in education, Selected references (Prepared for the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives). Washington, DC: U.S. Government Printing Office, 1971.

Constantine, Sister M. Radio in the elementary school. Science education, 1964, 48, 121-132.

Curtis, J. A. ITFS survey information (Information report #80-50). Williamsburg, VA: National Instructional Telecommunications Council, Inc., August 27, 1980.

Daynes, R., Brown, R.D., and Newman, D.L. Field test evaluation of teaching of with videodiscs. Educational and industrial television, March 1981, pp. 54,55-58.

Dooley, A. For bilingual instruction school shifting teaching aid to micros. Computerworld, November 6, 1978, p. 63.

Dwyer, T. A. Heuristic strategies for using computers to enrich education. International journal of man-machine studies, 1974, 6.

Dwyer, T. A. An extensible model for using technology in education. In R. J. Seidel (Ed.), Computers and communications: Implications for education. New York: Academic Press, 1977.

Edwards, J., Norton, S., Taylor, S. Weiss, M., and Dusseldorp, R. How effective is CAI? A review of the research. Educational leadership, 1975, 33, 147-153.

The effects of educational radio musical classroom (Report of the Radio-Television Cultural Research Institute). Tokyo: NHK, 1957.

Expanding educational opportunities through telecommunications (report of the Educational Telecommunications Project for Alaska). Juneau, AK: State Department of Education, February 1980.

Grayson, L. P. Costs, benefits, effectiveness: Challenges for educational technology. Science, 1972, 175, 1216-1222.

Grayson, L. P. Instructional technology: On diversity in education. Communication review, 1976a, 24 (2), pp. 117-134.

Grayson, L. P. Educational satellites: A goal or gaol? IEEE Transactions on education, 1976b, E-19 (2), pp. 38-45.

Grayson, L. P. Education, technology, and individual privacy. Educational communication and technology, 1978, 26 (3), pp. 195-206

Greenhill, L. P. Review of trends in research on instructional television and films. In Research in instructional television and film (U.S. Office of Education report OE-34041). Washington, DC: U.S. Government Printing Office, 1967, p. 1.

Hamblem, J. W., and Baird, T. B. Fourth inventory of computers in higher education, 1976-1977. Priceton, NJ: EDUCOM, 1979.

Hartley, S. S. Meta-analysis ofthe effects of individually paced instruction in mathematics (Doctoral dissertation, University of Colorado, 1977). Dissertation abstracts international, 1978, 38 (7-A), 4003. (University Microfilms No. 77-29, 926).

Heuston, D. H. The promise and inevitability of the videodisc in education. Orem, UT: WICAT, Inc., 1977. (ERIC Document Reproduction Service No. ED 153 636)

Hoban, C. F., and VanOrmer, E. B. Instructional film research, 1918-1950 (SDC 269-7-19). Port Washington, NY: U.S. Naval Training Devices Center, December 1950.

Hofstetter, F. T. Synopsis of the University of Delaware's Office of Computer-Based Instruction. Unpublished paper, University of Delaware, July 21, 1980.

How IBM uses videodiscs for customer training. Educational and instructional television, March 1981, 13 (3), 31-34.

Information technology in education (Report of the joint hearings of the Committee on Science and Technology and the Committee on Education and Labor of the U.S. House of Representatives, April 2,3, 1980). Washington, DC: U.S. Government Printing Office, 1980, p. 163.

Katzman, S., and Katzman, N. Public radio programming, Content by category, Fiscal year 1978. Washington, DC: Corporation for Public Broadcasting, 1978.

Kulik, J. A., Kulik, C-L. C., and Cohen, P. A. Research on audio-tutorial instruction: A meta-analysis of comparative studies. Research in higher education, 1979, 11 (4), 321-341.

Kulik, J. A., Kulik, C-L. C., and Cohen, P. A. Effectiveness of computer-based college teaching: A meta-analysis of findings. Review of educational research, winter 1980, 50 (4), 525-544.

LeBoss, B. 1980 could be the year of the consumer. Electronics, January 31, 1980, pp. 70-71.

Lee, S. Y. Status of public broadcasting 1980. Washington, DC: Corporation for Public Broadcasting, March 1981.

Long, H. A. The videodisc: A picture book in the round. T.H.E. journal, May 1981, 8 (4), 39-42.

Lumley, F. J. Rates of speech in radio speaking. Quarterly journal of speech, June 1933.

Luskin, B. J. Force or vision: The choice. T.H.E. journal, January 1981, 8 (1), 60-61.

Mathematics series. St. Louis, MO: Milliken Publishing Company.

MicroSIFT news, October 1980, 1 (1). Portland, OR: Northwest Regional Educational Laboaratory.

Milner. S. D., Determining the feasibility of computer-based instruction. Unpublished paper, Training Research and Evaluation Division, Workforce Effectiveness and Development Group, U.S. Office of Personnel Management, Washington, DC, October 1979, pp. 40-41.

Milner, S. D. How to make the right decisions about microcomputers. Instructional innovator, September 1980, 25 (6), pp. 12-19.

Molnar, A. R. National policy toward technological innovation and academic computing. Unpublished paper, Education Directorate, National Science Foundation, Washington, DC, 1977.

Molnar, A. R. Microcomputers and videodiscs: Innovations of the second kind. T.H.E. journal, November 1980, 7 (6), 58.

Murphy. R. T., and Appel, L. R. Evaluation of the PLATO IV computer-based education system in the community college (PR-77-10). Princeton, NJ: Educational Testing Service, 1977.

National Academy of Engineering. Issues and public policies in educational technology. Lexington, MA: Lexington Books, 1974.

Papert, S. et al. Final report of the Brookline LOGO project, and assessment and documentation of a children's computer laboratory. Cambridge, MA: Massachusetts Institute of Technology, 1973.

Postlethwait, S. N., Novak, J., and Murray, H. T., Jr. The audio-tutorial approach to learning (2nd ed.). Minneapolis, MN: Burgess Publishing Company, 1971.

Purser, R. E. Reference list of TRS 80, PET and APPLE II. El Dorado, CA: author, M.N.

Radio in the classroom (Report of the Wisconsin research project in school broadcasting). Madison, WI: University of Wisconsin Press, 1942.

Roth, E. B. Two-way television trains teachers. American education, November 1980, 16 (9), 20-28.

Scully, M. G. Use of television gaining on campuses after years of promise, disappointment. The chronicle of higher education, September 2, 1980, pp. 1, 14.

Scully, M. G. Annenberg's $150-million gift to public television to be used to produce courses for existing colleges. The chronicle of higher education, March 9, 1981, pp. 1, 15.

Shah, P. H., and Torok, G. P. Have blackboard, needn't travel. Bell Laboratories record, October 1979, 57 (9), 255-258.

Stegmann, C. Disco. New beat in do-it-yourself computer assisted instruction. Think, November/December 1980, 46 (6), 30-34.

Technology and education: Here comes the future. 1980 annual report. Princeton, NJ: Educational Testing Service, 1980, pp. 5-8.

Tickton, S. G. (Ed.) To improve learning: An evaluation of instructional technology, Part one, A report by the Commission on Instructional Technology. New York: Bowker, 1970.

Tickton, S. G. (Ed.) To improve learning: An evaluation of instructional technology, Part two, Instructional technology: Selected working papers on the state of the art. New York: Bowker, 1971.

Vinsonhaler, J. F., and Bass, R. K. A summary of ten major studies on CAI drill and practice. Educational technology, 1972, 12, 29-32.

Woelfel, N., and Tyler, I. K. Radio and the school (A summary of a six-year research project begun in 1937). Yonkers-on-Hudson, NY: World Book Company, 1945.

Yasutake, J. Y., and Stobie, W. H. Issues involved in AIS implementation: Closing the gap between theory and practice. Paper presented at the annual meeting of the American Educational Research Association, 1979.